GOING INTO BLAST WITH ANTHRACITE FURNACES.

BY T. EGLESTON, PH.D.

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The method of blowing in which is adopted in almost all the anthracite furnaces in the United States was imported originally from Staffordshire, and has been modified to suit the circumstances and conditions which arise from different situations, different fuels, different ores, and different shapes of furnaces. It is applicable to all kinds of fuel and is much safer and quicker than the method of scaffolding formerly used exclusively in charcoal furnaces, and still used in some of the European coke furnaces. With moderate care and precaution it has been so universally successful that a description of it cannot fail to be interesting.

When a furnace has been lined new, the first thing to be done is to place a good roof over the top so as to prevent the action of the weather. Then all the lower part of the furnace being open the air is sometimes allowed to circulate through it for several weeks in order to air dry it as much as possible. In most works in this country, however, no air drying is done. It is considered either that the furnace has been so long in repair that the masonry is dry enough, or, if business is good that they cannot afford to wait, so that the fire is started as soon as the masons have finished their work. When the furnace is ready, in open breast furnaces, a coal fire is made in the fore hearth which is transformed into a fireplace by building a temporary wall under the tymp and leaving a flue of about 10 inches square going directly into the furnace. The fore hearth is then arched over and a grate placed in it. The grate bars of the furnace will be about three feet long and the grate about 34 inches wide. As but little draft is required at first, the area of the flue is usually diminished by putting bricks into it. When the furnace has a closed breast, a temporary brick furnace 2 feet wide and 3 to 4

feet long is built outside of the furnace and the heat carried in by a flue built for the purpose. As soon as this is ready the top of the furnace is covered loosely with sheet iron supported on iron bars in order to prevent the too rapid escape of hot air.

A fire is then lit in the furnace which is kept up until there is no condensation of moisture anywhere about the colder parts of the furnace and all the inner brick feels dry. The dryer the furnace is before it is filled the better it will work and the longer it will last. Any time or fuel that is expended in this way in drying it, is extremely economical in its results, both for the preservation of the brick work and the lengthening of the campaign, so that for this reason drying should be carried as far as possible, and any fuel so expended will be economically used, so that for this reason the filling should be deferred until the last moment or until the furnace is perfectly dry. When business is pressing the time occupied is sometimes as short as ten days, but two months is a better time, the longer the time the better. It is not intended nor expected that all the moisture should be expelled in this way. When the newly constructed furnace goes into blast it will often continue to give off steam in small quantities from the moisture of the lining for a month after it is blown in. The length of the campaign, other things being equal, will, however, generally depend on the way the furnace is first dried.

While it is drying the tuyers should be put in, and all the water pipes should be tried to ascertain whether they are working perfectly. The blast engine should be started and all the pipes and valves connected with it and the blast main should be examined to see that they are ready to work. The nozzle should be examined and placed in readiness to put up at once.

When the furnace is ready the hearth is covered with sawdust, fine charcoal or anthracite dust to the depth of six inches at least. This is done to prevent any melted material which comes down after the furnace is fired, from sticking to the hearth. Sometimes no such precaution is taken, but the wood rests directly on the hearth. When the furnaces have a closed hearth a cribbing is made with eight inch to ten inch blocks, from eighteen inches to two feet high, to support the wood above, which is filled in with light wood or shavings only, just enough being put in to light the wood. This light wood being relieved of any pressure ignites very easily.

In the open breast furnaces a man gets into the hearth through the fore hearth, and fills it with sticks of cordwood from 4 to 4½ feet long, set on end, putting in generally only two tiers and filling the furnace to the height of eight to ten feet. As soon as the furnace is so full that there is no longer room to work, the man comes out through the fore hearth and fills up all the remaining space that he can from the outside, putting in at the last dried shavings and small wood in the spaces not filled by the cord-wood, so that the furnace will light easily. When the hearth has a closed breast all the filling is done from the top. The wood to be used should be hard and well seasoned, oak or hickory is preferred, but any other hard dry wood may be used.

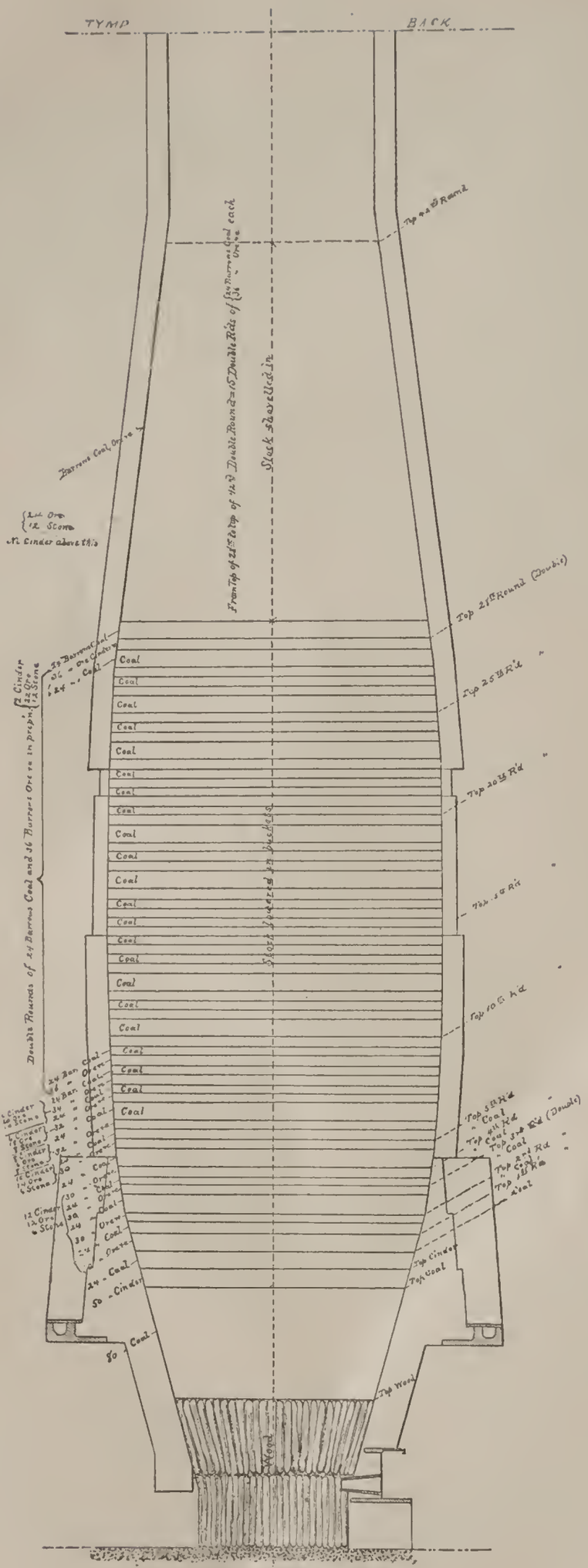
Long experience in the Lehigh district has shown that two tiers is about the best quantity of wood to be used. This is sufficient to light the furnace and any more than this may be injurious and likely to cause an accident. Occasionally the furnace is filled as high as 20 feet with wood, it being filled nearly to the boshes. There is always danger that an excess of wood above what is necessary to light the furnace will cause it to draw irregularly, the materials burning out at one side more than the other, and it may even cause an accident from excessive heat or produce a scaffold even before the blast is turned on. It is to be kept in mind always that when the wood burns out the stock must descend the whole height of the wood. If this took place suddenly it would cause a serious accident. It, however, takes place gradually, but much quicker than with the ordinary fuel, so that it must not be allowed to burn out too quickly, nor should there be too much of it. The time that it will take to put in the wood depends both on the quantity put in and the way it is introduced. If only two tiers are introduced from the fore hearth, as at Glendon, it will take about a day and a half. If it is lowered from the top it will take from six to twelve hours.

When the wood is filled in below, and every part of the space which is left has been filled as tight as possible, the dam is put in position. The cover is now removed from the top of the furnace. As the wood will reach to the height of the top of the hearth or higher, pieces of boards are placed against the boshes in order to protect the bricks in that position against abrasion from the material that is to form the charge. This is

very desirable, and as there is plenty of old lumber about the furnace which is useless for any other purpose, it is a matter of no expense. If, however, there is none, new boards must be used, and for this purpose slabs will answer as well as anything else. They should be placed close together so as to be sure that no abrasion will take place before the bricks have received their proper glaze. As soon as the cover is removed from the top of the furnace a tackle is rigged for the purpose of letting the materials down into the furnace. This is usually done in a bucket.

On top of the wood ten to twenty, and occasionally as high as thirty, tons of coal, varying with the size of the crucible, are then piled. This should be freshly mined coal, as almost all coal deteriorates by being kept, and serious accidents have happened to some furnaces owing to the fact that the coal they used in filling had been kept too long after mining. The coal is broken before being put into the furnace, to the size of six inches cube or steamboat size, and great care is taken to distribute it as uniformly as possible over the top wood, no fine coal whatever being used. In some works it is simply shoveled in from the top. This is a bad plan even for furnaces of less than sixty feet, and would be impossible in very large furnaces, since the height of the fall is so great as to break the coal and produce a great deal of fine dust, besides causing it to pack in the lower part. It is very undesirable, and may be dangerous.

It is much better to let down all the coal in buckets and level it carefully by hand. In some of the furnaces the coal is charged in buckets until the furnace is half full, and the rest is shoveled in from the top. In so important a matter the time and labor which is saved by working in this way is of no account, since the expense attendant upon any accident would necessarily be very great, and it is much better and more certain to be successful to fill the furnace entirely with buckets. For the rest of the filling the practice is a little different in the different works although the principle is the same everywhere. At Glendon, five-eighths the weight of the coal of carefully selected blast furnace cinder broken to the size of the fist is then put in. All the slag selected for this purpose should be very carefully chosen, that produced while gray iron is being made, being the best, and also slag which is very basic, as the substance that it is required to flux at this time is for the most part the ashes of the



No. 3 FURNACE.

Section of Stock showing Filling. Filled Oct. 14th, 1880. Weight of Barrow, 4 Cwt. Scale, 1 inch=12 feet.

fuel, which are for the most part acid. At Glendon the charges used in the furnace are known as the *single*, which is used in the normal working of the furnace, and the *double*, which is used in the first stage of the filling. The double charge is composed of 24 barrows of coal, 12 barrows of slag, 6 of limestone, and 12 of ore. The weight of the material per barrow is exactly the same for all kinds of material when filling. After four or five charges of this kind are made, two barrows of slag are replaced by two barrows of ore and one barrow of limestone, thus gradually substituting ore for cinder until it replaces it entirely, and the weight of the ore per charge is made equal to the weight of the coal.

In this way the furnace is filled to the top, a few charges at the last being of the regular or single charge, 12 barrows of coal, 6 of limestone, and 12 of ore. It is essential that these charges should be distributed as nearly as possible in horizontal layers, and that just as little fine material as possible should be used. This filling takes four to six days according to the size of the furnace. The annexed drawing for which I am indebted to Mr. F. Firmstone, shows the method of filling a No. 3 furnace at Glendon. At Bethlehem,* from 1500 to 2000 pounds of cinder are charged on the coal and at every tenth succeeding charge until the furnace is filled. The cinder is withdrawn when near the top by first putting in a charge of coal and 2000 pounds of slag, and then going on with the regular charge of ore, coal and limestone. The filling takes sixty hours. At Port Henry, as shown by the annexed table,† 500 lbs. of slag are put in to 3000 lbs. of coal, which is gradually increased to 2000 lbs. and then, when the furnace is about half full, as gradually decreased until it is withdrawn. The charge of ore is increased regularly with every three to five charges, so that by the time the furnace is filled, the ore will weigh from 1⅛ to 1¼ times the weight of the fuel. The amount of limestone is about five per cent. The time of filling is forty-eight hours, depending, however, on the way the

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* I am indebted to Mr. J. Fritz for details about the methods in use at Bethlehem.

† I am indebted to Mr. F. Witherbee for this Journal of the filling of one of the Port Henry furnaces.

Journal of a Filling at Port Henry.

Date.	Charges.	Common Limestone. Lime.	Magnesian Limestone. Magnesia.	Ore.	Cinder.	Coal.	Remarks.
1878.						lbs.	
Jan. 14	10						Cords of wood to top of bosh.
15	10					4000	
16	20	30	60		5- 500 5-1000 5-1500 5-2000	3000	
	5	90	180	600	5-1000		
	5	112	225	750	800		
17	5	135	276	900	600	3000	
	5	157	315	1050	400		
18	5	180	365	1200			
	5	202	405	1350			
	5	225	450	1500			
	5	247	495	1650			
	5	270	540	1800			
	5	292	585	1950		3000	
19	5	315	630	2100			
	5	337	675	2250			
	5	360	720	2400			
	5	382	765	2550		3000	
	5	405	810	2700			
	5	427	855	2850			
	5	450	900	3000			
	5	472	945	3150			Full to Flue.
20							Put in bell. Fired at 11.20 P. M.
21	10	472	945	3150			Full after wood burned out.
	11	517	1035	3400		3000	
Total charges.	131						
22	34	517	1035	3400		300	Put on wind at 2.35 P. M. Gas under boiler at 2.55 P. M. Gas into stoves at No. 1, 3.25; No. 2, 3.27; No. 3, 3.30. No explosions, cinder 10.10 P. M.
23	44	517	1035	3400		3000	Iron, 9 A. M., 17 tons.
24	41	517	1035	3400		3000	
25	10	517	1035	3400		3000	25¼ tons.
	30	540	1080	3600		3000	39¾ tons.

On April 6th, the furnace came up to 5,000 lbs. of Ore to 3,360 lbs. of Fuel.

hoist is worked and its capacity. The furnaces both at Bethlehem and Port Henry have closed breasts.

The use of cinder was formerly unusual, but has gradually grown into favor, as the cinder above the first coal not only begins to melt almost as soon as the blast is put on, thence running down into the fore hearth and warming the bottom, fluxing the ashes of the wood and the coal, but it also helps to glaze the bricks of the furnace. The success in blowing in will depend very largely upon the bricks getting the proper glaze. The iron which is first reduced instead of becoming scattered, as in the method of scaffolding it must do, amongst the cold ashes below, sinks through the melted slag as in the furnace in regular work. This employment of cinder has always worked well, and its use is constantly extending. The cinder which flows at first, is much more vitreous than that which has been put into the furnace. Its color is sometimes dark brown, from a little iron or other impurities, but is never black. When no cinder is added limestone is put in with the first coal in order to flux its ashes. The quantity of lime required is a little less than that used in the regular working. The regular filling commences at this point, the charge being let down in the same way, and each charge containing twice as much coal as what is to be the regular charge in the furnace. It is dangerous to use much fine ore while filling the furnace, as it is more likely to sift down through the charge and to pack, than during the regular working.

It is essential that sufficient space should be left between the parts of the charge to cause a good draft at the start. When the furnace is lighted the fire should come round regularly without any accident. There should be a good draft through the tuyers and under the tymp up into the furnace so that the fire will light regularly all around. A want of care in these respects will sometimes cause a great deal of difficulty. It is better generally to avoid the use of fine materials of any kind at this time.

While the filling is going on, if it has not been previously done, every part of the outside of the furnace should be examined to see that everything is in full working order, because it is desirable to light the furnace as soon as it is full. As this takes several days there is plenty of oportunity to examine

everything, for while a furnace may stand full of material for some time and blow in without any serious trouble, the charge is very apt to pack from standing, and serious accidents have occurred from allowing the furnace to be filled sometime before blowing in. Just as soon as the furnace is filled it should be lighted. This is done with shavings through the fore hearth which with all the openings at the bottom is left open, but the draft should be restricted so as to be certain that the wood does not burn too quickly. In the closed furnaces the lighting is done at the tap hole, cinder notch and tuyers at the same time, the ignition being often made with red hot iron bars put in through these openings.

If the draft is good as it should be, at the end of six to ten hours the fire will generally appear at the tuyers next to the fore hearth, and pieces of ignited coal will begin to drop in front of the tymp. The fore hearth is now filled up with coal dust, which is covered over with a layer of loam and packed down with a shovel. Over this two heavy cast iron plates are put for weights to keep it in position. If the furnace has been properly filled there is generally a strong draft at the tuyers, and the fire will work around gradually and quickly. It however, sometimes refuses to draw, when the weather becomes suddenly warmer than when the furnace was filled, because the materials inside are cooler than the outside air. If the draft is not good and the fire does not come round quickly, small nozzles may be put in and worked at a very low pressure by blowing in the open tuyer.

There is always danger in allowing the fire to come round slowly by itself, for in this case the wood in the center of the furnace may be completely converted into charcoal, or be burned out before that at the outside has begun to take fire, and thus cause an irregular descent of the charge. It is therefore desirable to put the nozzle in to hasten the fire if it does not come around properly. After about ten hours more, or 16 to 20 hours after the furnace has started, incandescent coal will begin to come down before the tuyers, which are closed at once with clay when this takes place.

As soon as the coal appears in front of the last tuyers, so that they have all been incandescent, they are all opened and the air is allowed to enter them in order to freshen up the fire

for about an hour before the blast is put on. The blast should be put on after no longer delay than this. At Glendon, the practice is to commence the blow gently as soon as all the wood is converted into charcoal. This is ascertained by thrusting a pointed iron rod through the tuyers. If there is no uncarbonized wood it can be pushed from wall to wall without difficulty. In some works the tuyers are not closed but the draft is obstructed or the tuyer left open according as there appears to be a necessity for more or less draft. This is more especially the practice in furnaces with a closed breast.

It will be possible if there is any accident, to bank the furnace at this time by stopping up all the tuyers and allowing it to remain so for 24 hours or even for twice that time, but there is always danger of scaffolds if at this stage any delay occurs in putting on the blast. There has been so much time to look after every part of the furnace and its machinery that there should be no accidents, as everything should not only be in perfect order but in good repair. The time from lighting to putting on the blast will be from 12 to 36 hours, depending somewhat on the weather but mostly on the filling.

Before blowing, good fires should be lighted on the grates of all the boilers to insure plenty of steam, and a fire of wood should be started in the combustion chamber of the hot blast stoves if they are iron, or in the center of the brick stoves if they are regenerative. All of these fires should be started two or three hours before the blast is put on, so as to warm the walls and the pipes. There should always be a bed of incandescent coal under the boilers, and in the combustion chamber of the hot air stoves when the blast is put on, which renders certain the ignition of the gas as soon as it enters them, and prevents an explosion which would be likely to take place if the gas did not at once become ignited there. It is not best to put on the blast before the gas at the top is combustible. It is not however best to light it before closing the bell, as explosions may occur in the space beneath the bell, or even in the interstices of the materials in the furnace. It is safest to commence with the charging bell open, and not close it until there is a good circulation of gas. The bell and all other outlets of gas are then closed almost tight and also all the valves leading from the gas flues to the stoves and boilers, thus driving all the air out ahead of the

gas through the small openings and leaks. By thus maintaining a good pressure in the flue an explosion is made impossible. When the air is out the valves must be opened very cautiously and one at a time. In some works the air is driven out by smoke from a smouldering fire made in the flues and combustion chambers and this is gradually replaced by gas. If a good fire has been kept up in the combustion chambers they will be well heated from the start, and no accident can take place. It is well always to maintain a plenum in the gas flues even when the furnace is in regular working. The bell should always be "chocked" open from the time the furnace is lighted until the gas is let into the flues, as explosions are liable to occur in the furnace itself. From such explosions the bell and hopper have sometimes been lifted from their seats and the brick work around them shattered, or both the bell and hopper broken, a serious thing at such a time, as it occasions delay. In the open breast furnaces the stopping should be put in before the blast is started. The time of firing should always be so selected that the blast shall be put on and the gas ignited in the day time.

About an hour after blowing is commenced the fore hearth is opened. If everything is in good working order at this time the fine dust and the loam, with which the fore hearth is filled, is removed from it, and stopping under the tymp is put in. The fore hearth is again filled, and the weights which cover it are put on and propped down.

In some of the furnaces a point is made of using smaller nozzles to blow in with than are used during the regular working, the diameter in some cases being reduced to two inches. These are kept in from 12 to 24 hours according to the way in which the furnace is driven. They are after this time changed for those used in the regular working. In others, tuyers of the full size are used from the beginning. The space between the nozzle and the tuyer is carefully packed with clay, open tuyers never being used in anthracite furnaces. In the best practice seats are turned in the tuyers into which the turned end of the nozzle fits; this not only prevents leaks, but greatly facilitates changing the nozzles.

After the blowing has commenced, fires should be started at once on top of the furnace and over the fore hearth, to ignite the gas as it escapes. If no accident has happened the material in the furnace will begin to sink regularly. As the charges descend

new charges are added, keeping up the same charge as that which was last put into the furnace. The gas will generally come off in considerable quantities, but will not be very combustible at first, as it is cold and filled with steam, for which reason the fires must be carefully looked after. The gas is used from the start. It will be about 36 hours before it can be depended on to be used without fires. It will be possible to increase the temperature in the course of five or six hours to 600° or 800° F. The slag will rise and appear in front of the tuyers in three to twelve hours after the blowing has commenced, depending on the way the charge is made and the size of the crucible. Whatever cinder is melted before the blowing commences settles in the hearth and no attention is paid to it in the closed breast furnaces After the blowing the slag is allowed to accumulate and runs off through the cinder notch ; sometimes the first cinder is tapped through the iron notch to warm up that part of the furnace, but this is not always done. In the open breast furnaces the condition of the slag must be carefully watched in order to "spring the cinder" into the fore hearth. In many of the works they wait to do this until the slag appears in front of the tuyers. In others the cinder is sprung as soon as the flames under the tymp and over the fore hearth commence to diminish or disappear. This shows that the slag has risen so high as to prevent the escape of the gases at that point, and that there is sufficient of it to fill the fore hearth. This is a much safer way, as it avoids every possible difficulty with the tuyers. To spring the cinder some of the blast is taken off, only enough being kept on to prevent the cinder from entering the tuyers. The weights and covers are removed from the fore hearth which is cleaned and the slag admitted into it by driving heavy iron bars down obliquely under the tymp. This admits the slag to the fore hearth, heats it up and gets it ready for the iron. As soon as the fore hearth is full of slag the weights are put on again, and the regular pressure of the blast resumed. If from the first appearance of the slag, or at any other time during the blowing in, there is any irregularity in its appearance the hearth is cleaned out.

The iron will begin to appear in from 12 to 20 hours. If the hearth should become choked with cold slag or pieces of unconsumed coal, it may appear sooner, and may even run over the dam, if proper attention is not paid to it In a sixty ton

furnace if everything is working well, the first cast will be from 14 to 15 tons, sometimes not more than 5 to 6 tons, but it is generally expected that it will be about one-third of the regular product. The normal working will usually not be arrived at in less than four or five weeks, but it is sometimes reached in two weeks.

The quantity of blast should be increased very slowly. There are two ways of doing it. One is to blow at a low pressure, and increase the quantity by increasing the pressure, and the other to commence at once with the full pressure and to increase the size of the nozzles. The latter seems to be the most rational although it gives more trouble, as the nozzles have to be removed. If the number of tuyers is greater than three or four it is well to reserve some of them at first and blow say from only half of them, but with the full pressure, as it is easier to start a new tuyer than to change a nozzle.

It is important to keep everything in the furnace moving regularly by properly handling the blast so as to prevent the danger of a hot scaffold, which is very apt to occur in blowing in if the blast is not properly handled. On no account should any attempt be made to force the furnace at first. It will not be economical so far as the length of the blast or of the campaign is concerned, to produce at once more than half or one third of what the furnace is expected to do in its normal working. Ordinarily the furnace will not get to its normal condition in less than a month or six weeks after it starts. Every possible precaution should be taken while the furnace is going into blast to avoid stoppages of any kind. It is impossible to tell what the effect of such stoppages will be, and every possible precaution should be taken to avoid them.

Failures by this method are extremely rare and when they occur they are usually caused either from the unskilful filling in of the furnace, from allowing the furnace to stand too long before it is fired, from the use of bad fuel, or too much fine ore, or from some delay. The most critical period is when the furnace is approaching its normal burden, which will generally be from two to three weeks after the blast is put on, for the maximum burden may or may not suit the conditions which are assumed for it, but by constant watchfulness with prompt action if needed, the furnace will generally work up to its proper condition without accident.